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Indian Standard

COAXIAL COMMUNICATION CABLES

PART 1-108 ELECTRICAL TEST METHODS — TEST FOR CHARACTERISTIC IMPEDANCE, PHASE AND GROUP DELAY, ELECTRICAL LENGTH AND PROPAGATION VELOCITY

ICS 33.120.10

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

February 2012 **Price Group 3**

Wires, Cables, Waveguides and Accessories Sectional Committee, LITD 06

NATIONAL FOREWORD

This Indian Standard (Part 1-108) which is identical with IEC 61196-1-108 : 2005 'Coaxial communication cables — Part 1-108: Electrical test methods — Test for characteristic impedance, phase and group delay, electrical length and propagation velocity' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Wires, Cables, Waveguides and Accessories Sectional Committee and approval of the Electronics and Information Technology Division Council.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 61196-1 : 2005 Coaxial communication cables — Part 1: Generic specification — General, definitions and requirements	IS/IEC 61196-1 : 2005 Coaxial communication cables: Part 1 Generic specification — General, definitions and requirements	Identical
IEC 61196-1-103 : 2005 Coaxial communication cables — Part 1-103: Electrical test methods — Test for capacitance of cable	IS/IEC 61196-1-103 : 2005 Coaxial communication cables: Part 1-103 Electrical test methods — Test for capacitance of cable	do

Only English language text has been retained while adopting it in this Indian Standard and as such the page numbers given here are not the same as in the IEC Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)' The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

COAXIAL COMMUNICATION CABLES

PART 1-108 ELECTRICAL TEST METHODS — TEST FOR CHARACTERISTIC IMPEDANCE, PHASE AND GROUP DELAY, ELECTRICAL LENGTH AND PROPAGATION VELOCITY

1 Scope

This part of IEC 61196 applies to coaxial communications cables. It specifies test methods for determining the characteristic impedance, phase and group delay, electrical length and propagation velocity of coaxial cables for use in telecommunications networks.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*

IEC 61196-1-103, *Coaxial communication cables – Part 1-103: Electrical test methods – Test for capacitance of cable*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61196-1 apply.

4 Parameters

From the phase constant β of a cable one can derive several parameters:

group delay
$$\tau_\mathrm{g} = \frac{d\beta}{d\omega} \approx \frac{\Delta\beta}{\Delta\omega} \qquad (1)$$

phase delay
$$\tau_\mathrm{p} = \frac{\beta}{\omega} \qquad (2)$$

propagation velocity
$$v = \frac{1}{\tau_\mathrm{p}} = \frac{\omega}{\beta} \qquad (3)$$

relative propagation velocity
$$v_\mathrm{r} = \frac{v}{c} = \frac{1}{\tau_\mathrm{p} \times c} = \frac{l_\mathrm{mech}}{l_\mathrm{e}} \qquad (4)$$

electrical length
$$l_\mathrm{e} = l_\mathrm{mech} \times \tau_\mathrm{p} \times c \qquad (5)$$

characteristic impedance
$$Z_\mathrm{c} = \frac{\beta}{\omega C} = \frac{\tau_\mathrm{p}}{C} \qquad (6)$$

where

β	is the phase constant in radian/m;
$\omega = 2\pi f$	is the angular frequency in radian/s;
τ_g	is the group delay in s/m;
τ_p	is the phase delay in s/m;
C	is the capacitance in pF/m;
c	is the propagation velocity in free space (3 x 10^8 m/s);
l_e	is the electrical length in m;
l_{mech}	is the mechanical length in m;
v	is the propagation velocity in m/s;
v_r	is the relative propagation velocity;
Z_c	is the characteristic impedance in Ω.

Those parameters are frequency-dependent and reach an asymptotic value at high frequencies. It is usual to measure them at frequencies higher than 200 MHz where the frequency is sufficiently high for the theoretical approximation always to be valid.

5 Test method

5.1 Equipment

A capacitance metre or bridge in accordance with IEC 61196-1-103.

A vector network analyser (VNA) capable of performing S21 measurements.

5.2 Test sample

Due to the cyclic behaviour of exp($-j\beta l$) a VNA can measure the phase constant β only in the range of –180° to +180° and does not give information on how many phase turns have already been completed at the lowest frequency. To avoid hidden phase turns, the maximum length of the sample should be:

$$l_{max} < \frac{500\,000}{Z_c \times C \times f} \qquad (7)$$

where

C	is the capacitance of the cable in pF/m according to IEC 61196-1-103;
f	is the the lowest frequency to be measured in MHz;
l_{max}	is the maximum possible sample length in m;
Z_c	is the nominal characteristic impedance of the cable.

5.3 Procedure

The S21 or S12 parameter of the sample shall be measured with the VNA. The phase constant obtained from this measurement is used to calculate the above-defined parameter.

The ambient temperature shall be recorded.

6 Expression of test results

6.1 Phase constant β

For the evaluation of the phase velocity, it is necessary to have full phase shift information. Normally, a VNA measures the phase in the range of $-\pi$ and $+\pi$. In this case, the phase shift shall be transformed into a monotonic decreasing function of frequency in the range of 0 and $-\infty$ (Figure 1). Some network analysers provide this function.

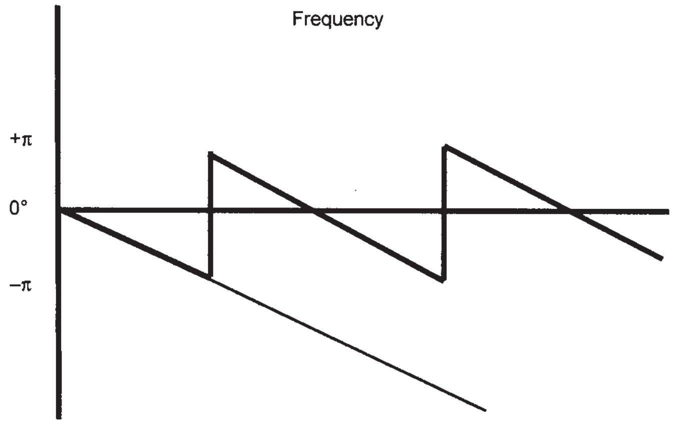

Figure 1 – Phase shift expanded

As an example, the following computation may be used.

```
For I = 2 To Number of frequency points
    K = 0
    WHILE Phase (I)> Phase (I-1)
        K=K+1
        Phase (I)=Phase (I)-K·2π
    END While
NEXT I
```

The phase constant β is then calculated by:

$$\beta(f) = \frac{\varphi_{\text{exp}}(f)}{l_{\text{sample}}} \tag{8}$$

where

$\beta(f)$ is the phase constant at frequency f in radians/m;

$\varphi_{\text{exp}}(f)$ is the expanded phase shift obtained from a S21 or S12 measurement in radians at the frequency f;

l_{sample} is the sample length in m.

6.2 Phase and group delay

Phase delay

$$\tau_\mathrm{p}(f) = \frac{\beta(f)}{2\pi \times f} \tag{9}$$

Group delay

$$\tau_\mathrm{g}(f) = \frac{\beta(f_2) - \beta(f_1)}{2\pi(f_2 - f_1)} \tag{10}$$

$$f_2 = f + \Delta f/2 \quad \text{if } f_2 > f_\mathrm{max} \quad \text{then } f_2 = f_\mathrm{max} \tag{11}$$

$$f_1 = f - \Delta f/2 \quad \text{if } f_1 < f_\mathrm{min} \quad \text{then } f_1 = f_\mathrm{min} \tag{12}$$

$$\Delta f \le 0{,}05 \times (f_\mathrm{max} - f_\mathrm{min}) \tag{13}$$

where

$\beta(f)$	is the phase constant in radian/m at frequency f;
$\tau_\mathrm{g}(f)$	is the group velocity in s/m at frequency f;
$\tau_\mathrm{p}(f)$	is the phase velocity in s/m at frequency f;
f_min, f_max	is the lowest respectively highest measured frequency in Hz.

6.3 Velocity of propagation

$$v(f) = 2\pi \times \frac{f}{\beta(f)} \tag{14}$$

$$v_\mathrm{r}(f) = \frac{v(f)}{c} = \frac{2\pi}{c}\frac{f}{\beta(f)} \tag{15}$$

where

$\beta(f)$	is the phase constant in radian/m at frequency f;
c	is the propagation velocity in free space (3×10^8 m/s);
f	is the frequency in Hz;
$v(f)$	is the propagation velocity in s/m at frequency f;
$v_\mathrm{r}(f)$	is the relative propagation velocity at frequency f.

6.4 Electrical length

$$l_\mathrm{e}(f) = l_\mathrm{mech} \frac{\beta(f) \times c}{2\pi \times f} \tag{16}$$

where

$\beta(f)$	is the phase constant in radian/m at frequency f;
c	is the propagation velocity in free space (3 x 10^8m/s);
f	is the frequency in Hz;
$l_e(f)$	is the electrical length in m at frequency f.

6.5 Characteristic impedance

$$Z_c(f)=\frac{1}{C}\times\frac{\beta(f)}{2\pi\times f} \qquad (17)$$

where

$\beta(f)$	is the phase constant in radian/m at frequency f;
C	is the capacitance in F/m;
f	is the frequency in Hz;
$Z_c(f)$	is the characteristic impedance in Ω at frequency f.

7 Test report

The test report shall give the following test conditions:

- temperature,
- sample length,
- test frequency

and record the values of:

characteristic impedance, phase and group delay, electrical length and propagation velocity.

8 Requirements

The values shall not exceed the requirements of the relevant detail specification.

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*

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